ON THE

COLOUR-TESTS FOR STRYCHNIA,

AND THE

DIAGNOSIS OF THE ALKALOIDS,

BEING THE SUBSTANCE OF PART OF

THE CROONIAN LECTURES FOR 1861,

Delivered at the Royal College of Physicians.

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ON THE

COLOUR-TESTS FOR STRYCHNIA AND THE DIAGNOSIS OF THE ALKALOIDS.

THE observations which I am about to make on the colour-tests for strychnia formed part of the three Croonian Lectures on Tabular Analysis, given at the College of Physicians at the end of February and beginning of March of this year. In those lectures, one form of tabular analysis was illustrated by a table of the alkaloids, and as the construction of the table grew out of a series of experiments on strychnia, and especially on the colour-tests for that important poison, it was necessary to enter into some details respecting those tests. The questions which I proposed to myself for solution were the following:—

1. The best form and mode of application of the colour-tests.
2. Of the colour-tests, which is to be preferred?
3. Are the colour-tests, or is the selected test, open to any serious objection?
4. Is it possible by means of the colour-tests, or by any simple modification of them, to distinguish the alkaloids from each other?

Before I proceed to discuss these questions, I must premise that most of the specimens of strychnia and of the other alkaloids on which I experimented were supplied to me by the Messrs. Morson. The majority of them were presented to me by them as specimens of approved purity; the remainder were procured from them from time to time. For a few specimens I was indebted to my colleague, Professor Bentley. Several of the alkaloids in Mr. Morson's series are crystals of large size and great beauty, and the remainder are evidently of the best quality; of some of the more important alkaloids, such as strychnia, brucia, and aconitina, I have more than one specimen. When the results which I obtained did not happen to agree with the descriptions of approved authorities, I made experiments with other specimens, and endeavoured to ascertain the reason of the discrepancy. I may add that the results stated in these papers are based upon several hundreds of experiments carefully performed, and the reactions noted down at the time. In order to guard against any possible misapprehension, it may be well to state that the term "colour-tests" is used throughout these communications in the sense of tests producing a series, or succession, of colours; and that it is further restricted to the chemical colour-tests as distinguished from the galvanic colour-test.

1. *Form and mode of application of the Colour-tests.*—The chemical colour-tests for strychnia consist in the peculiar reactions of the alkaloid with sulphuric acid, *plus* one or other of the following substances:—The bichromate of potash and the ferricyanide of potassium, and the peroxides of manganese and lead. To these may be added, as less generally recognized, the chromate of potash and chromic acid; and it may be well to state that the chromates of soda and ammonia yield characteristic reactions.

To the four recognized colour-tests—the bichromate of potash, the ferricyanide of potassium, the peroxide of manganese, and the peroxide of lead—I propose to add the permanganate of potash.

In order fully to appreciate the action of these tests, it should be borne in mind:—

1. That sulphuric acid, of the strength and degree of purity commonly met with in the shops, when added to, and mixed with ordinary specimens of strychnia, does not produce in them any change of colour.

2. That the acid does not occasion any change of colour in the peroxide of manganese or the peroxide of lead.

3. That the acid when mixed with a fragment of the bichromate of potash, produces a yellow solution, which passes gradually to a yellow-brown and clear orange.

4. That the acid when mixed with a fragment of the ferricyanide of potassium, gives a lemon-yellow solution, becoming tinged with blue after long exposure.

5. That the permanganate of potash treated in the same way yields with the acid a light green solution, deepening in tint by degrees, then assuming a pink tint at the margin, then, after longer exposure, becoming brown at the centre and lilac at the circumference, and finally, after still longer exposure, presenting a rich scarlet at the centre and a brown at the circumference.

Now, as the succession of colours produced when strychnia, sulphuric acid, and either of the five substances just specified are brought into contact, is entirely different from those occasioned by the action of sulphuric acid on the five substances in question, and as, moreover, the strychnia colours develop themselves very speedily, there is no valid objection to the use of these substances as tests. The yellow tint of the acid solution of the bichromate of potash, the lemon-yellow tint of the acid solution of the ferricyanide of potassium, and the light green tint of the acid solution of the permanganate of potash, offer no impediment to the development of the characteristic strychnia colours, and cannot possibly be confounded with them. The same observation applies equally to the mixture of sulphuric acid with the solutions of these salts. When solutions of the strength of ten grains to the ounce of distilled water are added to equal quantities of strong sulphuric acid, the bichromate of potash yields an orange coloured mixture, the ferricyanide of potassium a lemon-yellow, and the permanganate of potash a red-brown. The tints vary with the quantity of the acid and of the solutions, and they undergo some change on long exposure; but it may be safely alleged that the colours thus produced do not interfere with the production of the characteristic strychnia colours, and that they cannot possibly be confounded with them. But as for medico-legal purposes, it is well to avoid all objections, however captious, the peroxide of manganese, or the peroxide of lead, may claim to be preferred if, on further examination, they should be found to possess other properties entitling them to a preference.

Having shown that strychnia when treated with sulphuric acid undergoes no change of colour, and that the several tests (the peroxide of lead, the peroxide of manganese, the bichromate of potash, the ferricyanide of potassium, and the permanganate of potash) undergo either no change of colour, or such changes only as do not admit of being confounded with the strychnia colours, I proceed to consider in succession, 1. The best way of applying the colour-tests; 2. The best order in which to use the reagents; and 3. The best form in which to apply the colour-developing tests.

1. The colour-tests are best shown on slabs of glass coated with white arsenical enamel by the process technically called "flashing."* But the lids of porcelain

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* I have been in the habit of using this enamelled glass for colour-tests for several years. Oblong slabs of the kind described in the text may be obtained at Powell's Glass Works, Whitefriars.

crucibles, or white plates, or fragments of any white ware, will answer the purpose very well. If the enamelled glass is used the tests should be applied to the glass-surface. In using the tests scrupulous cleanliness should be observed, and the sulphuric acid and colour-developing tests, if in solution, are best applied by the drop-bottle, as more delicate, and more secure from any soil than the common glass rod. For mixing the several substances together a glass spatula is to be preferred to a glass rod.

2. The order in which ,the sulphuric acid and the colour-developing tests should be applied is easily determined by one or two simple considerations Good and characteristic results may be obtained by mixing the sulphuric acid with the colour-developing tests, and then adding a crystal of strychnia. When so mixed with small quantities of the peroxides of manganese and lead, the acid solution has a neutral tint, which in no way interferes with the full development of the strychnia colours; and even the acid mixtures of the other colour-developing tests are not open to any fallacy if the alkaloid is brought intc contact with them as soon as they are made, and before the colours first produced are deepened or changed by exposure to the air. But the method of procedure which begins with dissolving the alkaloid in the acid and then applying the colour developing tests is to be preferred, inasmuch as the absence of colour in the acid solution is some advantage in itself, as giving full effect to the strychnia colours, while it has the still greater advantage of distinguishing strychnia from several alkaloids (poisonous and non-poisonous), which yield colours with the acid without the addition of the colour-developing substances.

3. The best form in which to apply the colour-tests for strychnia is a subject of considerable practical importance, and it is one upon which there is at present no distinct agreement among Chemists. Some authorities prescribe the application of the colour-developing substances in the solid form, some in solution, and some who prefer the state of solution use strong solutions, while others employ weak ones. The balance of authority is certainly in favour of applying the colour-developing tests in the solid form, and my own experience is favourable to this mode of application. It is also commended by the obvious consideration that solution in water is favourable to a rapid development of the changing colours which constitute the test, such quick change of colour being among the most serious objections to the colour-tests. At any rate it must be admitted to be of the first importance to secure as slow a change of colour as possible, in order to give time for the observation of the colours actually produced.

The superiority of the solid form to the solution is easily shown by a comparative experiment. If we take two minute fragments of bichromate of potash of equal size, place them on a slab of white enamelled glass or porcelain, add to one of the fragments a drop of distilled water, and dissolve it in the water, and leave the other untouched; then place on the slab two equal drops of the same solution of strychnia in sulphuric acid, we shall find that on bringing the fragment of bichromate of potash into contact with the acid solution of strychnia, its colour changes from yellow to blue, and when stirred into the liquid with a glass rod or glass spatula, yields a rich blue solution, which retains this colour long enough for easy and complete identification, and then gradually assumes the other tints to be presently described, retaining the final tint for hours or days. While, on the other hand, the solution of the bichromate of potash, when brought into contact with the acid solution of strychnia, yields a blue colour at the point of contact, which colour quickly disappears on mixing the two liquids with each other. When, therefore, we make use of the colour-developing tests in substance, we obtain highly characteristic and lasting colours, but when we use them in solution, one evanescent colour only. It is true that if to the mixture of the acid solution of strychnia with the watery solution of bichromate of potash, we add a drop or two of strong sulphuric acid we obtain a blue liquid, which undergoes the characteristic changes of colour; but the important fact remains that, other things being equal, solution in water greatly impairs the delicacy of the colour-tests. If in this comparative experiment we substitute for the bichromate of potash the other soluble colour-developing substances—the ferricyanide of potassium and the permanganate of potash—we obtain the same results.

The injurious effect of dilution with water upon the colour-tests is differently shown in the following comparative experiment:—I placed on a porcelain slab four equal drops of the same solution of strychnia in strong sulphuric acid. To two of the four drops I added a drop of distilled water, and then to all the drops, diluted and undiluted, equal minute fragments of the bichromate of potash. The undiluted drops gave highly characteristic results—the usual succession of rich strychnia-colours; while the diluted spots gave no indication of the presence of strychnia, but merely a yellow solution. The same comparative experiment gave the same results with the ferricyanide of potassium, the permanganate of potash, and the peroxides of manganese and lead. The ferricyanide gave a lemon-yellow, and the permanganate of potash a pink, solution; while the peroxides of manganese and lead imparted a neutral tint. In multiplying this class of experiments I have now and then obtained a characteristic reaction, and occasionally an evanescent streak of blue; but these were exceptional cases.

The strength of the solution of strychnia in sulphuric acid used in both these series of experiments was one grain in 200 *drops*; and as the same *pipette* was used in preparing the solution and in the experiments, each drop contained the two-hundredth of a grain of strychnia.

Now these experiments, though they cannot be taken to prove that the dilution with water of the acid solution of the alkaloid, or the application of the colour-developing substance in solution, must be fatal to the success of the colour-tests, whatever the quantity of the alkaloid or of the acid, they do certainly demonstrate the great advantage attending the use of the colour-developing substances in the solid state. The experiments, it will be observed, are strictly logical and comparative. The distilled water added to the acid solution of the alkaloid, or to the colour-developing substance, was the only element of variation in the two series of experiments.

That the indistinct, or wholly negative, results obtained when distilled water is added are not due to mere dilution, or increase in the quantity of liquid present, is shown by the following experiment:—I placed five equal drops of the same solution of strychnia in sulphuric acid (1-200th grain in the *drop*) on each of three porcelain slabs. I made no addition to the first drop, but added to the second drop one drop of strong sulphuric acid; to the third, two drops; to the fourth, three drops; and to the fifth, four drops. I then added to each spot on the first slab an equal fragment of bichromate of potash; to each spot on the second slab, an equal fragment of peroxide of manganese; and to each spot on the third slab, an equal fragment of the permanganate of potash. The reactions were perfect and characteristic in each case, the colours differing only in depth of tint, but not in proportion to the degree of dilution. The peroxide of manganese was remarkable for the duration of the colours, and the permanganate of potash for their brilliancy.

Having now, as I believe, shown the superiority of the colour-developing tests in substance to the same tests in solution, and demonstrated the disadvantage of introducing into the colour-tests the element of dilution with water, I proceed to examine the effect of the quantity of the colour-developing substances on the success of the colour-tests.

The simple comparative experiments which I have described appear to warrant the conclusion that the colour-developing substances are best applied in the solid form; but it is quite possible that the quantity of these substances used in the experiments may sensibly affect the development of the strychnia-colours, I accordingly put this question to the test of experiment.

I placed four equal drops of the solution of strychnia in sulphuric acid ($\frac{1}{200}$ grain to the *drop*) on each of three white slabs. I added to the first group of four drops, bichromate of potash; to the second, peroxide of manganese; to the third, permanganate of potash: to the first drop, in each case, a minute fragment of the test, and to the second, third, and fourth drops, a larger and larger fragment. This simple experiment yielded the following results:—With the bichromate of potash I obtained a perfect result with the smallest quantity of the salt, but with the larger quantities only the characteristic primary colour: the last secondary colour, or the colour which the mixture assumes after exposure for one or two minutes, was yellow-brown instead of bright brick red. With the peroxide of manganese I obtained two perfectly characteristic results with the two smaller quantities, but with the larger quantities less characteristic secondary results. In the first two experiments with the smaller quantities the mixture assumed the usual clear bright brick red as the ultimate tint, while in the third and fourth experiments it continued for a long time to retain the second or mulberry tint. With the permanganate of potash the reaction was quite characteristic in the two experiments with the smaller quantities of the salt, but the third assumed, after short exposure, a pink, instead of a vermilion tint, and the fourth took on at once a rich red-brown tint, and, therefore, failed as a test.

It is evident, therefore, from these experiments, in which all the elements were equal, except the quantity of the colour-developing substance, that in order to ensure a successful and in every way characteristic result, we must operate with small quantities of the colour-developing reagents. We must use small fragments of the substance in question. If we think that we are dealing with such quantities of the alkaloid as the two-hundredth of a grain, we should use a fragment not exceeding the size of an ordinary pin's head; and this quantity, small as it is, should be reduced if we have reason to believe that the quantity of the alkaloid falls short of this small amount.

I am now in a condition to give a distinct answer to the first of the four questions which I undertook to examine. The best *mode* of applying the colour-tests for strychnia is to dissolve the alkaloid in the acid, and then to apply the colour-developing substance; and the best *form* in which the two elements of the test—the sulphuric acid and the colour-developing reagent—can be used is, the acid concentrated and the reagent in substance. This appears to be a fair inference from the experiments already detailed.

But the experiments teach something more than this. They demonstrate the close dependence ot the experiments, if they are to prove successful and characteristic, on the apportionment of the quantity and strength of the reagents. The injurious effect of even moderate dilution of the acid with distilled water shows that it should be applied as the strong acid, and affords a reason for its employment in the most concentrated form; the failure, more or less complete, of a fragment of the colour-developing substance when dissolved in a drop of water, contrasted with the perfect success of its counterpart when applied in the solid form, is conclusive as to the superiority of the solid to the liquid state; and the perfectly characteristic results obtained with the colour-developing re-agents in small quantity, contrasted with the less characteristic results yielded by larger quantities, proves that the quantity of those reagents which we employ is by no means an unimportant element in the success of our experiments.

But though the combination of a concentrated sulphuric acid with the colour-developing reagents in the solid state is that which promises the best results, and is most likely to detect strychnia if present, it does not follow that either the moderate dilution of the acid or the use of the colour-developing reagents in solution may not give very characteristic results. Every one, indeed, who has been in the habit of showing the colour-tests for strychnia in the class-room must know that failures rarely, if ever, occur, whatever the mode and form of application of the tests. But it should be borne in mind that for class purposes it is usual to employ a quantity of the alkaloid much exceeding the two-hundredth of a grain contained in the drop of acid as used in the experiments I have been describing. Even with this small quantity of strychnia, solutions of the three soluble tests—bichromate of potash, ferricyanide of potassium, and permanganate of potash,—in the proportion of 10 grains to the ounce of distilled water, gave rise, with occasional exceptions, to such a distinct development of the first colour, as to leave no doubt of the presence of strychnia, though the after colours were fleeting, variable, and wanting in distinctness. These experiments, then, justify the use of the colour-developing tests in solution as tests for strychnia, but it may admit of doubt whether in medico-legal cases we should be so fortunate as to deal with quantities of strychnia large enough to yield characteristic results with the reagents in a state of solution, however concentrated. I am of opinion, from the experiments I have detailed, as well as from the more general results of my experience of the strychnia-tests, that for medico-legal purposes the colour-developing reagents should always be added to the acid solution of the supposed alkaloid in substance, and not in solution.

My conjecture, that the success of class experiments in which the colour-developing tests are used in solution, depends on the use of a larger quantity of strychnia than the two-hundredth of a grain, was confirmed by actual trial; for I found that with these larger quantities, the tests in solution developed the same characteristic colours, or very similar ones, as those brought out by the same tests in substance.

2. The second question, namely, *Of the colour-tests for strychnia, which is to be preferred?* cannot be properly discussed without some preliminary inquiry into the true meaning of the colour-tests, and some description of the succession of colours which constitute those tests.

The colours produced by the action of the peroxides of manganese and lead, the bichromate of potash, the ferricyanide of potassium, and the permanganate of potash, on a solution of strychnia in strong sulphuric acid, are usually described as deep blue, passing to violet, purple, and red, and after long exposure, passing to light red.

This description of the colour-tests is sufficiently faithful for every practical purpose, and it applies to all the colour-tests and to all specimens of strychnia of the usual purity. It admits, however, of being simplified with advantage by specifying three principal colours passing into each other by insensible gradations. The first and most characteristic colour is a rich blue or purple, the second a claret, and the third a bright orange. The first colour may be compared to the bloom of the Orleans plum, the second to the mulberry, the third to the peel of the sweet orange. This is the succession of colours in the majority of experiments, but the exceptions to the rule are very numerous, and will be presently more particularly mentioned.

When the colour-developing test is applied to the solution of strychnia in strong sulphuric acid, and immediately stirred into it with a glass rod or spatula, the first colour is well marked, and lasts for from half a minute to forty-five seconds; the second colour during one, two, or three minutes; and the third colour for several hours or days. But when the acid solution is diluted with distilled water, or the colour-developing test is applied in solution, the first colour only may be produced, and that indistinctly and transiently, or the test may wholly fail. It will succeed in developing all the colours only when the quantity of the alkaloid is considerable. It should also be understood that, even when the experiment is made in the manner just described, the results are by no means uniform. Some of the exceptions to the rule will appear in the issue of the comparative experiments now to be detailed.

I made two series of these experiments. I first compared the peroxide of manganese with the peroxide of lead. I then made a similar comparison of the three soluble salts, the bichromate of potash, the ferricyanide of potassium, and the permanganate of potash; and having selected from each group the best and most characteristic reagent, proceeded to compare the two so selected with each other.

I made the two series of experiments in the same way. I used in both cases a number of small slabs of white porcelain, equal drops of the acid solution of strychnia ($\frac{1}{200}$th grain to the drop), and equal fragments of the reagents.

In the first series of experiments I placed side by side two rows of porcelain slabs, twenty in each row; on each slab of the one row, a drop of the acid solution, and a fragment of the peroxide of manganese; and on each slab of the other row, an equal drop of the same solution, and an equal fragment of the peroxide of lead. I stirred the several fragments into the several drops of acid in the same way, and obtained highly characteristic results with the peroxide of lead in every instance; but with the peroxide of manganese there were three instances in which the first colour was imperfectly developed. In the other cases the first colour was very distinctly produced. But the action of the peroxide of lead was certainly more speedy and more delicate, as well as more constant, than that of the peroxide of manganese. The solitary advantage possessed by the peroxide of manganese consisted in the greater permanence of the third colour. But as this advantage is very small, as compared with the quickness, delicacy, and certainty of the action of the peroxide of lead, in developing the first and most characteristic of the strychnia-tints, I had no hesitation in selecting the peroxide of lead as the better of the two insoluble tests.

The experiment with the three soluble tests was conducted in the same manner with three rows of 20 slabs each, and it issued in showing the superiority of the permanganate of potash over the bichromate of potash and the ferricyanide of potassium in the richness and clearness of the first and most characteristic tint. The subsequent colours were also clearly brought out. But the permanganate of potash resembled the bichromate of potash in exhibiting less permanency in the third tint than did the ferricyanide of potassium. It resulted from a careful comparison of these three tests that the permanganate of potash is to be preferred to the other two.

There remained, therefore, to be submitted to a further comparative experiment the peroxide of lead, as the better of the first group of two, and the permanganate of potash, as the best of the second group of three.

The comparative experiment for this purpose was the exact counterpart of those just described. Twenty experiments with the peroxide of lead were compared with twenty similar experiments with the permanganate of potash. The result was decidedly in favour of the permanganate of potash, which gave in every case a clear rich blue colour, while the colour with the peroxide of lead was less clear and bright, being sometimes obscured by the colour of the portions not dissolved. In two of the experiments the result was not satisfactory.

I repeated these comparative experiments with several stains left by the evaporation of solutions of strychnia in benzole, and found the permanganate of potash to yield characteristic results where the peroxide of lead failed. I estimated the quantity of strychnia in these stains at less than the thousandth of a grain. The permanganate of potash acted characteristically in every instance.

Having thus ascertained the superiority of the permanganate of potash to the peroxide of lead, I made a final experiment with the three soluble colour-developing substances: the permanganate of potash, the ferricyanide of potassium, and the bichromate of potash. I took eighteen glass slides stained with deposits of strychnia, some from the solution of the alkaloid in benzole, and others from a solution of the acetate decomposed by the vapours of ammonia. I arranged the eighteen stains in groups of three, putting those of equal size together, and I noted the results at once by the position of the slides. All the spots were first treated with a single drop of strong sulphuric acid. The acid solutions were then treated with equal small fragments of the colour-developing substances, six with the permanganate, six with the bichromate, and six with the ferricyanide. In one group of three all the reagents failed. This experiment was, therefore, excluded. But the remaining five groups gave the following results:—

The ferricyanide of potassium gave faint indications of strychnia in two instances, and failed in three.

The bichromate of potash acted characteristically once, gave faint indications twice, and failed twice.

The permanganate of potash acted quite characteristically five times, producing a clear brilliant blue solution, changing to mulberry and to bright red.

In these last experiments I estimate the quantity of strychnia in the stains at about the $\frac{1}{1500}$ of a grain.

The answer to the second question—of the colour-tests for strychnia, which is to be preferred?—is, therefore, evidently in favour of the permanganate of potash. The remaining questions must be reserved for future consideration.

I now proceed to discuss the third of the four questions propounded in my first communication, namely, Are the colour-tests, or is the selected test, open to any serious objection?

Of chemical tests in general, it may be said that they are more or less liable to the following objections or disparagements:—1. They may be wanting in delicacy; that is to say, they may not be able to detect minute quantities of the substances to which they are applied as tests. 2. They may be wanting in certainty; in other words, they may fail from slight causes difficult to appreciate and define, such as the quantity or proportion in which they are applied, or the strength of their solutions if used in the form of liquid. 3. They may give rise to transient effects, or to appearances difficult to describe or define. 4. They may be unusually liable to failure from impurities in themselves, or in the matters to which they are applied as tests. And, lastly, they may produce of themselves appearances nearly allied to those which they occasion when added to the matters under examination.

From the first of these objections all the colour-tests for strychnia are certainly free. They are able to detect very minute quantities of the poison. From the fourth objection, too, as it will presently be shown, they are at least as free as the majority of chemical tests. To the second, third, and last objections they are certainly exposed, but under what circumstances and in what degree, it will be necessary to inquire.

The occasional failure of the colour-tests for strychnia from slight and obscure causes is not to be denied. It is proved by the experiments already detailed, and is admitted by all experienced chemists. But it should be understood that this objection has only a limited application. It goes only to the extent of impairing the value of the evidence derived from a negative result. If the colour-tests fail when applied to a spot acted on by sulphuric acid, their failure is not conclusive evidence of the absence of the poison. It affords a strong probability of such absence, but nothing more.

The reactions of the colour-tests for strychnia are certainly transient. They are not like the permanent white, crystalline, or coloured precipitates afforded by most chemical tests. But the objection on this ground is also of limited application. In experiments with the colour-tests made in the manner described in a former communication, we obtain two classes of results. We may get a mere trace or "flash" of blue, or we may obtain a deep rich blue colour, lasting for several seconds, for half a minute, or even for forty-five seconds, and succeeded by the other tints already described. Now those who maintain the value of the colour-tests for strychnia do not pretend that a mere flash of colour affords such evidence of the presence of strychnia as could be used with safety in a court of law; but they would probably be found to assert with equal confidence that a deep rich blue colour, developed by the colour-producing tests for strychnia, and continuing for several seconds in a spot previously treated with sulphuric acid without change of colour, and then succeeded by other colours, affords good evidence of the presence of strychnia. Though the blue colour soon passes away, there is ample time afforded for its complete recognition.

In answer to the objection that the succession of colours is difficult to describe or define, it will suffice to state that though it may not be possible by any words that we can use to describe the successive colours developed by the colour-tests, it is not necessary to do so. For the first deep rich blue colour, characterized by the property of want of permanence, is in itself so remarkable as to constitute a most valuable and trustworthy test for strychnia.

The colour-tests for strychnia are certainly open to the objection that the colour-developing substances are themselves coloured. The peroxide of lead is puce coloured, the peroxide of manganese black, the bichromate of potash orange coloured, the ferricyanide of potassium yellow or orange, and the permanganate of potash lilac. The peroxide of lead and the peroxide of manganese also colour sulphuric acid by admixture, and the bichromate of potash, ferricyanide of potassium, and permanganate of potash change the colour of the acid by solution. But it has been shown that the colours thus produced cannot possibly be confounded with the strychnia blue, and consequently form no valid ground of objection.

The fourth of the five objections applicable to chemical tests in general, certainly does not apply with any force to the colour-tests for strychnia; for I can state as the result of experiments with a great variety of substances vegetable and animal, including all the matters that are likely to remain mixed with strychnia after its extraction from the contents of the stomach, or from the fluids and tissues of the body, and further with many mineral substances, including common salt, arsenious acid, tartar emetic, and corrosive sublimate—all these animal, vegetable, and mineral substances having been added in quantities far exceeding those in which they could possibly exist as impurities in strychnia extracted from the contents of the stomach, or from the fluids and tissues of the body—that the colour-tests are little, if at all, affected by such admixtures. This observation applies to the permanganate of potash equally with the bichromate of potash.

For practical purposes the reaction which demonstrates the presence of strychnia may be described as a clear rich blue colour, developed by the colour-tests in a spot previously treated by strong sulphuric acid without change of colour, the blue colour in question lasting long enough for perfect recognition, and then passing into other colours. In the absence of the blue colour we can affirm the probable absence of strychnia, but a mere flash of colour does not afford a degree of evidence upon which we ought to rely in a medico-legal inquiry.

Assuming the description just given to be correct, I now proceed to inquire whether there are any known substances which give rise to a similar reaction. The answer must be, in a qualified sense, in the affirmative; but it must be understood that the reaction is only *similar,* not the *same.*

Such a substance is to be found in cod-liver oil, which, when treated with strong sulphuric acid, assumes a purple tint, mixed with streaks of blue, changing after a time to mulberry, and from that to a red-brown. In these changes of colour there is such a general resemblance to the strychnia tints as would justify their being put forward as an objection to the colour-tests, but for the very obvious consideration that with sulphuric acid alone strychnia undergoes no change of colour. The very fact, too, that cod-liver oil is an oil, while strychnia is tested either as an alkaloid or the salt of an alkaloid, as a crystal or as a white powder, or as a dry deposit from a liquid holding it in solution, deprives this objection to the colour-tests for strychnia of all practical value.

Again, aniline is mentioned as a source of fallacy. But aniline is a coloured liquid, which yields with sulphuric acid a dense white precipitate, the sulphate of aniline. Strychnia, on the other hand, is a crystal or white powder, or a dry deposit from a liquid holding it in solution.

But the sulphate of aniline which is formed by adding the strong sulphuric acid to the liquid aniline, is sold as a white powder, as are some specimens of strychnia. Hence the sulphate of aniline might possibly prove a source of fallacy, inasmuch as it gives no change of colour with sulphuric acid, and yet when treated with the colour-producing substances, yields a colour similar to the blue of strychnia. But the sulphate of aniline, in place of a rich deep blue passing speedily into mulberry and at length into bright red, assumes at first a pale green, which deepens by slow degrees, then passes into a beautiful blue, continuing unchanged for a long period, but at length turning to a black. So that the first characteristic colour with strychnia is the second with aniline, and the transient colour with strychnia is persistent with aniline.

Again, there is a red crystalline substance, pyroxanthine, which produces with sulphuric acid alone, without addition of the colour-producing tests, a blue similar to that produced by strychnia. But there is here no real fallacy, because strychnia is not coloured, and does not yield any colour with sulphuric acid alone.

Nor do papaverine and narceine, which are tinged purple by sulphuric acid alone, create any difficulty, or occasion any fallacy. And the same may be said of the whole body of alkaloids and active principles, whether coloured or colourless, which yield colours when treated with sulphuric acid alone. Of those which resemble strychnia in giving no colour with sulphuric acid, it may be stated with equal confidence, that not one of them yields with the colour-developing substances the true strychnia colours, or any colours resembling them.

The foregoing are given as examples of the sort of objections that are urged against the colour-tests for strychnia. They belong to the class of objections which no one out of a court of law would bring forward as worthy of serious attention. They are based, not so much on a misapprehension of the facts, as on an illogical comparison of dissimilar phenomena. But there is one objection founded on a misapprehension and quite unintentional misrepresentation, which ought not to be passed over in silence. It is stated by Dr. Taylor, in his work on Poisons, that the alkaloid curarina obtained from the South American poison curara "resembles strychnia in the action of the colour-tests, brucia in the action of nitric acid, and both in its intense bitterness." These are the words used by Dr. Taylor, at p. 786 of the second edition of his work; and on referring to p. 772, he says of the same alkaloid, that "strong nitric acid produces with it a blood-red colour; sulphuric acid gives with it a rich carmine tint, in which characters it resembles brucia," and further that Pelikan found pure curarina to possess the chemical properties of strychnia, so far as the colour-tests are concerned, and with more constant results. Thus sulphuric acid when conjoined with the action of chromate of potash, ferricyanide of potassium, or peroxide of lead, "produced a beautiful play of colours," and that "the galvanic test acted similarly." Now, on referring to the passage cited from Pelikan, I find that this beautiful play of colours is a translation of the words "des colorations rouges très belles," and "la coloration rouge," the one expression being applied to the chemical tests, the other to the galvanic test. So that the alkaloid curarina is set up as a fallacy on the strength of its yielding with the colour-tests (sulphuric acid mixed with chromate of potash, ferricyanide of potassium, or peroxide of lead a brilliant red colour, or colours, instead of the beautiful play of colours, blue, mulberry, and red, which jointly, and not separately, characterize strychnia. If any one colour is to be deemed the strychnia colour *par excellence*, it is the rich, deep blue, and not the brilliant red. Let it also be remembered that sulphuric acid gives with curarina, according to Bernard, a rich carmine tint, while strychnia undergoes no change of colour when treated with sulphuric acid. The statement made by Dr. Taylor that in giving a blood-red colour with strong nitric acid and a rich carmine tint with sulphuric acid, curarina resembles brucia, is evidently founded in error. The reaction of brucia with nitric acid is correctly stated, but brucia certainly does not yield a carmine tint with sulphuric acid. It is one of the list of substances grouped together in my tables as characterized by a negative action with sulphuric acid; and Mr. Jenkins, in the table which I sent round in my last lecture, attributes to it a negative reaction with sulphuric acid (see *Chemical News*, Oct. 6, 1860); and here I may observe that it is one of the obvious advantages of tables such as these, that they place before us the common and familiar reactions of the substances which they comprise, in such an orderly and methodical way as greatly to assist the memory, and to guard against such inadvertent statements as this of Dr. Taylor's respecting brucia.*

On referring to the tests for brucia itself, as given at page 801 of Dr. Taylor's work on Poisons from which I have been quoting, I find it stated that "strong sulphuric acid colours brucia of a rich rose-pink colour." This colour differs widely from the rich carmine (*belle teinte carminée*) of Bernard, said by Dr. Taylor to be characteristic of the same reaction, and I think that I may venture to state of it that it is not the reaction of pure brucia with pure sulphuric acid. Indeed, it is not the reaction of specimens of brucia of ordinary purity with specimens of sulphuric acid of similar purity. To obtain a rich rose pink with brucia, we must use a specimen of sulphuric acid containing an unusual quantity of nitric acid, and I have no doubt that the unintentional use of such an acid gave rise to this misapprehension. I may add, that to specimens of brucia of fair average quality, sulphuric acid will impart a very slight tint (rose colour or buff), and a still slighter tint to the solution of the alkaloid in the acid. But a rich rose-pink colour is an evidence of the presence of nitric acid, and is readily developed in the solution of the alkaloid in sulphuric acid by a short exposure to the vapour of nitric acid.

I could not have accomplished the object I have in view of vindicating the colour-tests for strychnia from unfounded objections, without tracing this particular objection to its true source. It was necessary to show that the reactions of the rare alkaloid, *curarina*, differ essentially from those of strychnia, and of brucia, which is associated with strychnine in more than one of the plants that yield it; and I could not do this without showing that an esteemed medico-legal authority had made a mistake in reference to a reaction, and an oversight in rendering the words of a French author.

I may add, that on comparing the extract of nux vomica with a specimen ot curara poison, for which I am indebted to the kindness of Mr. Morson, and with the brown powder scraped from an arrow tipped with the same poison, and forming one of a collection kindly presented to me by Mr. Stone, of the College of Surgeons, I find no resemblance between the one extract and the other, except in the property of intense bitterness. The woorara poison imparts to strong sulphuric acid a greenish-brown tint, and the nux vomica a pink colour; while strong nitric acid, which turns the first to a pale, dirty yellow, changes the second to a very distinct orange colour. The addition to the solution in sulphuric acid of bichromate of potash produces less effect on the colour of the curara than takes place with the extract of nux vomica. If the woorara really contained any alkaloid capable of developing with sulphuric and nitric acids the deep rich colours attributed to it, I think that some approach to those colours might be expected in the extract itself.

I may conclude this part of my subject by expressing my firm conviction that to the colour-tests applied in the manner I have recommended, there is no valid logical objection; and that though a negative result is not conclusive of the absence of strychnia, a positive result (by which I must be understood to mean the development of a rich blue colour on stirring the colour-developing sub stances into a spot first treated with sulphuric acid without change of colour the rich blue colour in question passing, after a few seconds, into other colours) affords undeniable proof of its presence.

The last of the four questions proposed for solution in my first communication still remains to be discussed. It relates to the diagnosis of the alkaloids, and was expressed in the following terms:—Is it possible by means of the colour-tests, or by any simple modification of them, to distinguish the alkaloids from each other?

Before proceeding to examine this question I must briefly refer to what I have already stated respecting the colour-tests. These tests, as commonly understood, are compound tests, consisting first of the reaction of the alkaloid with sulphuric acid, and then of the reaction of the peroxides of lead and manganese, the bichromate of potash, the ferricyanide of potassium, and the permanganate of potash, with the mixture of the alkaloid and sulphuric acid.

The sulphuric acid produces in strychnia no change of colour. Hence the acid itself becomes a test of no mean value. It serves, as I shall point out more particularly presently, to distinguish strychnia from a considerable number of the alkaloids, and also from several substances which give with sulphuric acid alone coloured reactions, some of which reactions with the acid alone bear a certain resemblance to those of strychnia with sulphuric acid *plus* the bichromate of potash, ferricyanide of potassium, permanganate of potash, peroxide of lead, or peroxide of manganese. In order to distinguish strychnia from other alkaloids, and from the substances to which I have just referred, it is essential that the sulphuric acid should be first applied to, and well mixed with, the strychnia, and that the absence of colour having been noted, the reagents that develop the colour should be in their turn applied. In all that I have said on the subject of the colour-tests for strychnia, and in what I have yet to say, I assume this mode of procedure to be strictly observed; and I shall continue to speak of these reagents as the colour-producing tests.

I have hitherto assumed that the sulphuric acid is applied *cold;* but I shall presently point out that we may greatly add to the value of this constituent portion of the colour-tests by first warming and then heating the acid solution. A very slight rise of temperature serves to develop very beautiful and characteristic colours in some of the alkaloids, while it does not change the colour of strychnia. A further rise of temperature to the point of causing the mixture to give off vapour, develops colour in strychnia also, and deepens or changes the tints already imparted to the alkaloids previously affected by warming the acid mixture.

The colour imparted to a solution of strychnia in sulphuric acid by raising it to a temperature at which it gives off vapour is not strongly marked. It is a faint yellow or light greenish-brown, differing somewhat in depth of tint with different specimens of strychnia treated in all respects exactly alike. If the acid solution is allowed to cool it no longer acts characteristically with the bichromate of potash or the other tests. Their action is wholly destroyed or greatly impaired. Hence in applying the colour-tests for strychnia we must use concentrated pure sulphuric acid, and use it *cold.*

So much for the first part of the colour-tests. We add to the alkaloid under examination sulphuric acid in small quantity—pure, strong, and cold; and it undergoes no change of colour. The alkaloid, therefore, whatever it may be, belongs to the class of which strychnia is one.

To this cold acid solution of the alkaloid we add a minute fragment of bichromate of potash, ferricyanide of potassium, permanganate of potash, peroxide of lead, or peroxide of manganese. The result is the remarkable development of successive transient, or short-lived, colours already described.

The negative reaction of strong cold sulphuric acid on strychnia, followed by the effect of heat on the acid mixture, and this by the peculiar colours produced by the application of the colour-developing substances to the cold acid mixture, constitute a series of phenomena which afford fair promise of proving the means of a successful diagnosis of the alkaloids.

To this work of distinction I now address myself, and in order to prepare the way more completely for the work of tabular analysis towards which the details given in my former communications have been tending, I must again revert to the question whether the action of the colour-tests on strychnia is, or is not, characteristic, and therefore, diagnostic.

This is a question which must have suggested itself to every chemist engaged in medico-legal inquiries as of the utmost practical importance, and one chemist (Mr. Thomas E. Jenkins) having been employed to investigate a case of suspected poisoning in which the colour-tests gave indications of the presence of strychnia, very properly put the question to the test of experiment, by applying to a variety of active principles, including most of the alkaloids, first, colourless concentrated sulphuric acid, and then a fragment of a crystal of bichromate of potash. The experiments, which were carefully performed, and appear to have been strictly comparable one with another, embraced no less than fifty alkaloids and active principles, derived from the animal as well as the vegetable kingdom, and among them, urea and uric acid, and cantharidine. More than half of these substances differed from strychnia in yielding colour when treated with sulphuric acid. The smaller half resembled strychnia in this respect. But not one of the whole fifty gave with the bichromate of potash the characteristic coloured reactions of strychnia. Feeling that my time would not be wasted in repeating these experiments, and if possible extending them to substances not included in his list, I possessed myself (partly by the kind assistance of Mr. Morson) of all the alkaloids and similar active principles which could be obtained, and tested them in the same way. To Mr. Jenkins's list, some of which I was not able to procure, I succeeded in adding as many as sixteen new substances. None of these gave the characteristic coloured reactions of strychnia, nor any succession of colours any way resembling them, so that I am now in a condition to assert that strychnia stands alone among sixty-six analogous compounds in the reactions which it gives with sulphuric acid followed by the bichromate of potash.

Mr. Jenkins (as will be seen in the table published by him in the *Chemical News* for October 6, 1860) arranges his reactions in two columns. The first column displays the effect produced by strong sulphuric acid; the second, the changes of colour caused by the addition to the acid solution of the bichromate of potash.

Now this table affords an excellent illustration of the absence of method and logical arrangement. The substances operated on evidently took their places as they chanced to come to hand. Strychnia itself has to be sought out; and substances which give coloured reactions with sulphuric acid, find themselves in contact with others that give a negative result.

And yet the table seems to court the attention of lovers of method and logical order. It is almost impossible to keep one's hands off it. At least one would like to place the substances which are not coloured by sulphuric acid by themselves, and those that are coloured also by themselves. I have undertaken this work of tabulation, and, on inspecting the result, am seized with the same desire to resume the work of arrangement. In both groups there are substances which yield with bichromate of potash the same colours. Why should not these similar reactions be bracketed together? This accordingly I have carried into effect, and the result is a splitting up of the fifty substances into several groups of such moderate dimensions, that a man given to tabular analysis can scarcely resist the additional temptation to try whether some modification of the tests themselves, or some additional tests, or both together, may not lead to a successful separation and elimination of each and all the substances contained in the table.* I now proceed to lay before you in a tabular form the results of a very laborious experimental attempt to distinguish some of the principal alkaloids and active principles, whether derived from the vegetable or animal kingdom, from each other.

As the first object which I had in view was to distinguish the poisonous alkaloids and analogous active principles from each other, these substances are of course admitted into the tables; but I have added to these the active principles of many of our aperient medicines and common articles of diet; and have excluded only such of those substances as were so strongly characterized by colour or odour, as not to be properly grouped with the colourless, or faintly-coloured, and inodorous alkaloids and active principles.† The table, divided for convenience into two, consists, as it is, of as many as thirty-five different substances, closely resembling each other in physical properties and chemical composition, and offering collectively a very difficult subject for tabular analysis.

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* In the lectures given at the College of Physicians, Mr. Jenkins's original table, and the two tabular arrangements alluded to in the text, were sent round. These tables were the more freely used as illustrations of a want of logical arrangement, as the author evidently did not aim at diagnosis, but only at the distinct ascertainment of the peculiar and characteristic reactions of strychnia. The remarks in the text were not, therefore, intended in any respect as a censure of Mr. Jenkins for not adopting an arrangement which, for his purpose, was unnecessary. I may add, that his table comprises several substances which will not be found in the tables I am about to submit. I mean such substances as the kinic and kinovic acids, and such animal products as urea and uric acid.

† To this statement it will be seen that there are one or two exceptions, such as naphthaline, which, though colourless, has the odour of tar.

The tables, as you have them before you, are the result of a long series of experiments, and were only made to assume their present form after a great many experimental groupings and transpositions.

The first object which I had in view was to find some simple test which would divide the whole body of active principles comprised in the two tables into two principal groups. Concentrated sulphuric acid, as a constituent of the strychnia colour-tests, was obviously well adapted to this purpose. It has the effect of dissolving the alkaloids and active principles *without change of colour* in the case of one considerable group (Table I.), *and with change of colour* in the case of another considerable group (Table II.). The first group (Table I.) comprises the majority of the active poisonous principles — strychnia, brucia, morphia; atropine, picrotoxia, aconitina; and the animal principle cantharadine. With these and several other alkaloids and active principles, some of which are very harmless ones, concentrated sulphuric acid either produces no change of colour, or a faint yellow, straw, or buff tint.* I speak of *cold concentrated* sulphuric acid, applied as in the preliminary to the colour-tests for strychnia.

The next object which I had in view was to subdivide these two large groups (Tables I. and II.) each into two or more smaller groups by some second test, which might also, perchance, produce in some members of the two groups characteristic reactions, so as to eliminate or separate them at once. For this purpose I tried the effect of warming the acid solution of the alkaloids by passing the porcelain slab through the flame of the spirit lamp, so as to raise the temperature of the liquid to a point short of that at which it gives off vapour. This subsidiary test answered its purpose completely; the group of substances in Table II. which had already given colours, more or less characteristic, with the cold acid, underwent further changes of colour, more or less peculiar; while the group in Table I. which had undergone no change with the cold acid, became subdivided into two leading groups, of which one continued without colour, and the other underwent changes of colour more or less characteristic. In the instances of meconine and of aconitina, the colours developed proved to be peculiar to these substances, so as to lead at once to their elimination from the rest.

By raising still further the temperature of the acid solutions to a point at which vapour was given off, a further separation into distinct groups or classes was found to take place. The six substances which stand first in order in Table I. still remained colourless, while the remainder assumed tints more or less characteristic. Esculine and atropine; picrotoxia, santonine, and narcotine; amygdaline and naphthaline, formed themselves into three distinct groups; while strychnia, brucia, and morphia gave indications of colour less distinct and characteristic.

By this triple test of sulphuric acid, *cold*, *warmed*, and *heated*, the active principles contained in this division (Table I.) have been either eliminated, or split up into manageable groups, awaiting the application of further tests. It seemed natural to select as the next test in order nitric acid—a known characteristic test of brucia and morphia. By applying this test to the several members of the table in succession, codia was isolated from the group of six to which it belonged by the distinct yellow colour assumed by the acid solution. Emetine was, in like manner, isolated from the other members of the same group of six, by yielding with the acid a yellow-brown colour. Atropine, again, was distinguished from esculine by giving a negative result, while esculine assumed a distinct yellow colour. In the same way narcotine was detached from its group of three, and naphthaline from its group of two. Again, morphia was distinguished by the rich orange hue given by the acid, together with the red fumes of nitrous acid; and brucia was effectually distinguished from strychnia by the intense red of the former contrasting with the faint tinge of red imparted to ordinary specimens of the latter. For the next eliminating test I have selected sulphuric acid followed by a solution of permanganate of potash, in the proportion of 10 grains of the salt to ℥j. of water. The effect of this test on strychnia was to develop its characteristic colours, strongly contrasted with the altogether different colours given with brucia, and still more with the brown colour imparted to morphia, followed by the bleaching of the liquid. This same test divided the somewhat unmanageable group of four at the top of the table (cantharadine and asparagine, and caffeine and cinchonine) into two small groups of two each. In the first two the immediate effect of the permanganate was a red-brown colour; in the second, a pink. Picrotoxia and santonine gave the same colour (pink) and remained undistinguished. The last and ultimate work of elimination was effected by means of heat applied to the active principle in its solid state. Cantharadine was found to be wholly dissipated by the heat of the spirit lamp, while asparagine gave a bulky carbonaceous deposit. And caffeine was found to present the same difference when compared with cinchonine. Lastly, picrotoxia was found to be distinguished from santonine by the bulky carbonaceous residue with the first, and the scanty deposit of carbon with the second.

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* I ought to state in this place that some of the alkaloids are very sensitive to heat, so that a very slight rise of temperature is followed by a decided development of colour. Hence it is possible that experiments made in a cold room in winter may yield results differing somewhat from the same experiments made in a warm room in the height of summer. It must also be borne in mind that sulphuric acid, if not free from nitric acid, may impart to some of the alkaloids a tint of rose, yellow, or buff, sufficiently deep to justify their removal from Table I. to Table II. It may be well, therefore, to state that the experiments on which the tables are founded were made in the winter, in a room with a fire, but in the morning, before the temperature of the room had been raised to a point approaching summer-heat; and that the acid employed was free from nitric acid.

Having by this succession of tests obtained a clue to the active principle with which we have been dealing, we should proceed to identify the substance indicated by the table, through its own characteristic tests.

In the second division of the one large table of elimination, or that which comprises active principles coloured by contact with cold sulphuric acid (Table II.), the same succession of tests is employed. Cold concentrated sulphuric acid at once separates this group of seventeen into eight smaller groups of one, two, or six; and the subsequent warming and heating of the coloured acid solutions occasions such marked differences of colour as to nearly complete the work of elimination. But I have added columns showing the effect of nitric acid, and of the solution of permanganate of potash. The application of heat to the alkaloids themselves did not prove necessary to the work of elimination.

I submit these tables primarily as specimens of *Tables of Elimination;* but also incidentally as tables which may prove serviceable to the Chemist. I am not certain that they constitute the best aid which could be devised to the diagnosis of the alkaloids. I thought that they might, perhaps, admit of being simplified by adding to the three columns headed "sulphuric acid" a fourth, showing the deposit of carbon resulting from the continued application of heat to the acid solution of the alkaloid. I tried this reaction in the case of fourteen alkaloids and active principles, comprising all the more active poisons of this class, together with the less important principles, emetine and meconine, and found the alkaloids to differ from each other in the amount of carbonaceous deposit. With strychnia, aconitina, and veratria, for instance, the deposit of carbon was less abundant than with brucia, morphia, atropia, and the other poisonous alkaloids. But the difference was not such as to justify me in using it as a diagnostic property. So also with the direct application of heat to the alkaloids themselves. Strychnia, morphia, atropia, cantharadine, meconine, picrotoxia, and delphinia, after melting, deposited but a scanty carbonaceous ash; while emetine, aconitina, and digitaline yielded an abundant ash; and brucia, elaterine, veratria, and solanine, yielded an ash intermediate in quantity. This test, again, though fairly applicable to the few cases in Table I., did not seem admissible as a diagnostic on a larger scale. Indeed, the tables, though carefully compiled and based on carefully conducted experiments, are open to the obvious objection that, with different specimens and different quantities of the alkaloids, and with different specimens of sulphuric acid, we may obtain differences of tint, and more or less ready development of colour under increase of temperature. The majority of the reactions, however, will, I believe, be found constant for all specimens of fair average purity. One alkaloid, hyoscyamia, which I was not able to procure, is omitted.*

Of the two tables, Table I. affords the best illustration of a table of elimination. For the sake of brevity, and for other reasons already explained, the figures 1, 2, 3, are added to the words describing the colours developed by the tests. These figures indicate different degrees of intensity. In comparing strychnia with brucia, for instance, the figure (^{1}) attached to the word "yellow" opposite strychnia in the third column means a faint yellow colour, less in degree than that indicated by the figure (^{2}) opposite brucia in the same column. So the word "brown" with the annex (^{3}) in the same column opposite esculine and atropine indicates an intense brown colour; the words red ^{3} and orange ^{3} in the column headed nitric acid indicate intense red and orange respectively.

TABLE I.

ALKALOIDS, &C., GIVING NO COLOUR WITH COLD SULPHURIC ACID.

Alkaloids, &c.	Sulphuric Acid.			Nitric Acid.	Sulphuric Acid, followed by the solution of Permanganate of Potash.	Heat.
	Cold.	Warm.	Hot.			
Cantharadine	0	0	0	0	Red brown	0
Asparagine	0	0	0	0	Red brown	Carbon^3
Caffeine and Theine	0	0	0	0	Pink	0
Cinchonine	0	0	0	0	Pink	Carbon^3
Codia	0	0	0	Yellow		
Emetine	0	0	0	Yellow-brown		
Strychnia	0	0	Yellow^1	Pink^1	Blue, mulberry, orange	
Brucia	0	0	Yellow^2	Red^3	Red, brown, orange, yellow	
Morphia	0	0	Brown	Orange^3	Brown, then bleached	
Esculine	0	0	Brown^3	Yellow		
Atropine	0	0	Brown^3	0		
Meconine	0	Blue				
Aconitina	0	Brown				
Picrotoxia	0	Yellow	Brown	0	Pink	Carbon^3
Santonine	0	Yellow	Brown	0	Pink	Carbon^1
Narcotine	0	Yellow	Claret	Yellow		
Amygdaline	0	Pink	Brown	0		
Naphthaline	0	Pink	Brown	Yellow		

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* In the lectures at the College of Physicians a table was used which showed the colours actually produced by the action of the several reagents on these poisonous alkaloids and active principles.

TABLE II.

ALKALOIDS, &c., GIVING COLOUR WITH COLD SULPHURIC ACID.

Alkaloids, &c.	Sulphuric Acid.			Nitric Acid.	Sulphuric Acid, followed by the solution of the Permanganate of Potash.
	Cold.	Warm.	Hot.		
Veratria	Orange^3	Scarlet	Claret	0	
Piperine	Orange^3	Red-brown	Green^3	Orange^3	
Delphinia	Pink^1	Pink^2	Brown	0	Yellow^1
Salicine	Pink^1	Pink^3	Claret	0	Claret
Digitaline	Red-brown^1	Red-brown^2	Red-brown^3	0	Buff
Elaterine	Red-brown^1	Red-brown^2	Red-brown^3	0	Pink^3
Papaverine	Purple^3	Purple^2	Purple^1	Yellow	Green; slate
Paramorphia	Purple^1	Purple^1	Purple^3	Yellow	Green; brown
Quina	Yellow	Yellow	Yellow-brown	Yellow	
Aloine	Yellow	Yellow^3	Green	Orange	
Jalapine	Yellow	Orange^3	Red-brown	Yellow	
Narceine	Yellow	Red-brown^3	Red-brown^3	Green-brown^3	Buff
Phloritzin	Yellow	Red-brown^3	Red-brown^3	Red-brown^3	Pink^3
Solania	Yellow^3	Brown^2	Brown^3	0	
Cubebine	Pink^3			Yellow	
Quinoidin	Brown	Brown	Brown	0	
Sanguinarine	Red-brown^2	Claret	Claret	Red-brown^2	